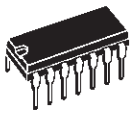
TS914

RAIL TO RAIL
CMOS QUAD OPERATIONAL AMPLIFIER

- RAIL TO RAIL INPUT AND OUTPUT VOLTAGE RANGES
- SINGLE (OR DUAL) SUPPLY OPERATION FROM **2.7V TO 16V**
- EXTREMELY LOW INPUT BIAS CURRENT : **1pA** typ
- LOW INPUT OFFSET VOLTAGE : **2mV max.**
- SPECIFIED FOR **600Ω** AND **100Ω** LOADS
- LOW SUPPLY CURRENT : 200µA/Ampli (V_{CC} = 3V)
- LATCH-UP IMMUNITY

- **SPICE MACROMODEL** INCLUDED IN THIS SPECIFICATION



N
DIP-14
(Plastic Package)

D
SO-14
(Plastic Micropackage)

DESCRIPTION

The TS914 is a RAIL TO RAIL CMOS quad operational amplifier designed to operate with a single or dual supply voltage.

The input voltage range V_{icm} includes the two supply rails V_{CC}^+ and V_{CC}^-.

The output reaches :

- V_{CC}^- +50mV V_{CC}^+ -50mV with R_L = 10kΩ
- V_{CC}^- +350mV V_{CC}^+ -350mV with R_L = 600Ω

This product offers a broad supply voltage operating range from 2.7V to 16V and a supply current of only 200µA/amp. (V_{CC} = 3V).

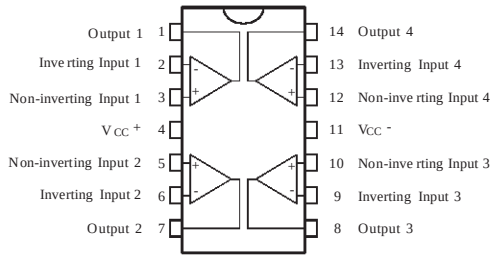
Source and sink output current capability is typically 40mA (at V_{CC} = 3V), fixed by an internal limitation circuit.

ORDER CODE

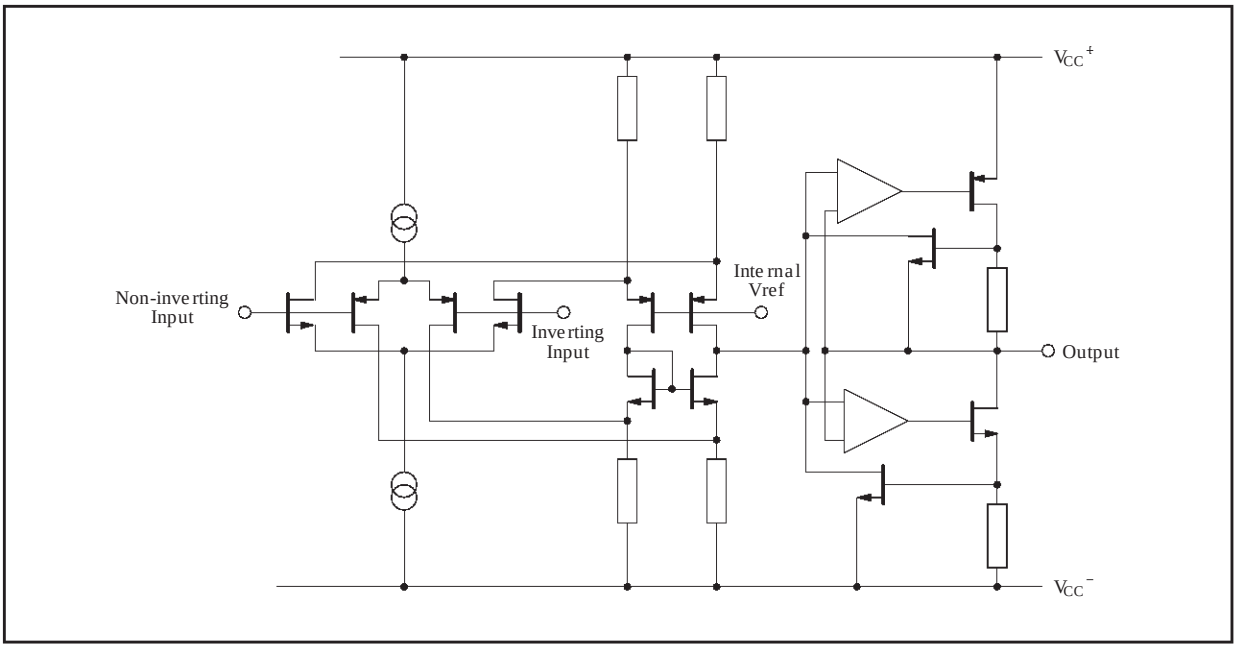
Part Number	Temperature Range	Package	
		N	D
TS914I/AI	-40, +125°C	•	•

N = Dual in Line Package (DIP)
D = Small Outline Package (SO) - also available in Tape & Reel (DT)

PIN CONNECTIONS (top view)



SCHEMATIC DIAGRAM (1/2 TS914)



ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Value	Unit
V_{CC}	Supply voltage [1]	18	V
V_{id}	Differential Input Voltage [2]	±18	V
V_i	Input Voltage [3]	-0.3 to 18	V
I_{in}	Current on Inputs	±50	mA
I_o	Current on Outputs	±130	mA
T_{oper}	Operating Free Air Temperature Range TS914I/AI	-40 to + 125	°C
T_{stg}	Storage Temperature	-65 to +150	°C

1. All voltages values, except differential voltage are with respect to network ground terminal.
2. Differential voltagesare non-inverting input terminal with respect to the inverting input terminal.
3. The magnitude of input and output voltages must never exceed V_{CC}^+ +0.3V.

OPERATING CONDITIONS

Symbol	Parameter	Value	Unit
V_{CC}	Supply voltage	2.7 to 16	V
V_{icm}	Common Mode Input Voltage Range	V_{CC}^- -0.2 to V_{CC}^+ +0.2	V

ELECTRICAL CHARACTERISTICS

V_{CC}^+ = 3V, V_{cc}^- = 0V, R_L, C_L connected to $V_{CC/2}$, T_{amb} = 25°C (unless otherwise specified)

Symbol	Parameter		Min.	Typ.	Max.	Unit
V_{io}	Input Offset Voltage ($V_{ic} = V_o = V_{CC/2}$)	TS914 TS914A			10 5	mV
	$T_{min.} \le T_{amb} \le T_{max.}$	TS914 TS914A			12 7	
ΔV_{io}	Input Offset Voltage Drift			5		µV/°C
I_{io}	Input Offset Current [1] $T_{min.} \le T_{amb} \le T_{max.}$			1	100 200	pA
I_{ib}	Input Bias Current [1] $T_{min.} \le T_{amb} \le T_{max.}$			1	150 300	pA
I_{CC}	Supply Current (per amplifier, A_{VCL} = 1, no load) $T_{min.} \le T_{amb} \le T_{max.}$			200	300 400	µA
CMR	Common Mode Rejection Ratio V_{ic} = 0 to 3V, V_o = 1.5V			70		dB
SVR	Supply Voltage Rejection Ratio (V_{CC}^+ = 2.7 to 3.3V, $V_o = V_{CC/2}$)			80		dB
A_{vd}	Large Signal Voltage Gain (R_L = 10kΩ, V_o = 1.2V to 1.8V) $T_{min.} \le T_{amb} \le T_{max.}$		3 2	10		V/mV
V_{OH}	High Level Output Voltage (V_{id} = 1V)	R_L = 10kΩ R_L = 600Ω R_L = 100Ω	2.9 2.2	2.97 2.7 2		V
	$T_{min.} \le T_{amb} \le T_{max.}$	R_L = 10kΩ R_L = 600Ω	2.8 2.1			
V_{OL}	Low Level Output Voltage (V_{id} = -1V)	R_L = 10kΩ R_L = 600Ω R_L = 100Ω		50 300 900	100 600	mV
	$T_{min.} \le T_{amb} \le T_{max.}$	R_L = 10kΩ R_L = 600Ω			150 900	
I_o	Output Short Circuit Current (V_{id} = ±1V)	Source ($V_o = V_{CC}$) Sink ($V_o = V_{CC}^+$)		40 40		mA
GBP	Gain Bandwith Product (A_{VCL} = 100, R_L = 10kΩ, C_L = 100pF, f = 100kHz)			0.8		MHz
SR	Slew Rate (A_{VCL} = 1, R_L = 10kΩ, C_L = 100pF, V_i = 1.3V to 1.7V)			0.5		V/µs
ϕm	Phase Margin			30		Degrees
en	Equivalent Input Noise Voltage (R_s = 100Ω, f = 1kHz)			30		nV/√Hz
V_{O1}/V_{O2}	Channel Separation (f = 1kHz)			120		dB

1. Maximum values including unavoidable inaccuracies of the industrial test

ELECTRICAL CHARACTERISTICS

V_{CC}^+ = 5V, V_{cc}^- = 0V, R_L, C_L connected to $V_{CC/2}$, T_{amb} = 25°C (unless otherwise specified)

Symbol	Parameter		Min.	Typ.	Max.	Unit
V_{io}	Input Offset Voltage ($V_{ic} = V_o = V_{CC/2}$)	TS914 TS914A			10 5	mV
	$T_{min.} \le T_{amb} \le T_{max.}$	TS914 TS914A			12 7	
ΔV_{io}	Input Offset Voltage Drift			5		µV/°C
I_{io}	Input Offset Current [1] $T_{min.} \le T_{amb} \le T_{max.}$			1	100 200	pA
I_{ib}	Input Bias Current [1] $T_{min.} \le T_{amb} \le T_{max.}$			1	150 300	pA
I_{CC}	Supply Current (per amplifier, A_{VCL} = 1, no load) $T_{min.} \le T_{amb} \le T_{max.}$			230	350 450	µA
CMR	Common Mode Rejection Ratio V_{ic} = 1.5 to 3.5V, V_o = 2.5V			85		dB
SVR	Supply Voltage Rejection Ratio (V_{CC}^+ = 3 to 5V, $V_o = V_{CC/2}$)			80		dB
A_{vd}	Large Signal Voltage Gain (R_L = 10kΩ, V_o = 1.5V to 3.5V) $T_{min.} \le T_{amb} \le T_{max.}$		10 7	40		V/mV
V_{OH}	High Level Output Voltage (V_{id} = 1V)	R_L = 10kΩ R_L = 600Ω R_L = 100Ω	4.85 4.20	4.95 4.65 3.7		V
	$T_{min.} \le T_{amb} \le T_{max.}$	R_L = 10kΩ R_L = 600Ω	4.8 4.1			
V_{OL}	Low Level Output Voltage (V_{id} = -1V)	R_L = 10kΩ R_L = 600Ω R_L = 100Ω		50 350 1400	100 680	mV
	$T_{min.} \le T_{amb} \le T_{max.}$	R_L = 10kΩ R_L = 600Ω			150 900	
I_o	Output Short Circuit Current (V_{id} = ±1V)	Source ($V_o = V_{CC}$) Sink ($V_o = V_{CC}^+$)		60 60		mA
GBP	Gain Bandwith Product (A_{VCL} = 100, R_L = 10kΩ, C_L = 100pF, f = 100kHz)			1		MHz
SR	Slew Rate (A_{VCL} = 1, R_L = 10kΩ, C_L = 100pF, V_i = 1V to 4V)			0.8		V/µs
ϕm	Phase Margin			30		Degrees
en	Equivalent Input Noise Voltage (R_s = 100Ω, f = 1kHz)			30		nV/√Hz
V_{O1}/V_{O2}	Channel Separation (f = 1kHz)			120		dB

1. Maximum values including unavoidable inaccuracies of the industrial test

ELECTRICAL CHARACTERISTICS

V_{CC}^+ = 10V, V_{DD} = 0V, R_L, C_L connected to $V_{CC/2}$, T_{amb} = 25°C (unless otherwise specified)

Symbol	Parameter		Min.	Typ.	Max.	Unit
V_{io}	Input Offset Voltage ($V_{ic} = V_o = V_{CC/2}$)	TS914 TS914A			10 5	mV
	$T_{min.} \le T_{amb} \le T_{max.}$	TS914 TS914A			12 7	
ΔV_{io}	Input Offset Voltage Drift			5		µV/°C
I_{io}	Input Offset Current [1] $T_{min.} \le T_{amb} \le T_{max.}$			1	100 200	pA
I_{ib}	Input Bias Current [1] $T_{min.} \le T_{amb} \le T_{max.}$			1	150 300	pA
V_{icm}	Common Mode Input Voltage Range		V_{DD} - 0.2 to V_{CC}^+ 0.2			V
CMR	Common Mode Rejection Ratio V_{ic} = 3 to 7V, V_o = 5V V_{ic} = 0 to 10V, V_o = 5V			90 75		dB
SVR	Supply Voltage Rejection Ratio (V_{CC}^+ = 5 to 10V, $V_o = V_{CC/2}$)			90		dB
A_{vd}	Large Signal Voltage Gain (R_L = 10kΩ, V_o = 2.5V to 7.5V) $T_{min.} \le T_{amb} \le T_{max.}$		15 10	60		V/mV
V_{OH}	High Level Output Voltage (V_{id} = 1V)	R_L = 10kΩ R_L = 600Ω R_L = 100Ω	9.85 9	9.95 9.35 7.8		V
	$T_{min.} \le T_{amb} \le T_{max.}$	R_L = 10kΩ R_L = 600Ω	9.8 9			
V_{OL}	Low Level Output Voltage (V_{id} = -1V)	R_L = 10kΩ R_L = 600Ω R_L = 100Ω		50 650 2300	180 800	mV
	$T_{min.} \le T_{amb} \le T_{max.}$	R_L = 10kΩ R_L = 600Ω			150 900	
I_o	Output Short Circuit Current (V_{id} = ±1V)			60		mA
I_{CC}	Supply Current (per amplifier, A_{VCL} = 1, no load) $T_{min.} \le T_{amb} \le T_{max.}$			400	600 700	µA
GBP	Gain Bandwith Product (A_{VCL} = 100, R_L = 10kΩ, C_L = 100pF, f = 100kHz)			1.4		MHz
SR	Slew Rate (A_{VCL} = 1, R_L = 10kΩ, C_L = 100pF, V_i = 2.5V to 7.5V)			1		V/µs
ϕm	Phase Margin			40		Degrees
en	Equivalent Input Noise Voltage (R_s = 100Ω, f = 1kHz)			30		nV/√Hz
THD	Total Harmonic Distortion (A_{VCL} = 1, R_L = 10kΩ, C_L = 100pF, V_o = 4.75V to 5.25V, f = 1kHz)			0.02		%
C_{in}	Input Capacitance			1.5		pF
R_{in}	Input Resistance			>10		Tera Ω
V_{O1}/V_{O2}	Channel Separation (f = 1kHz)			120		dB

1. Maximum values including unavoidable inaccuracies of the industrial test

TYPICAL CHARACTERISTICS

Figure 1 : Supply Current (each amplifier) vs Supply Voltage

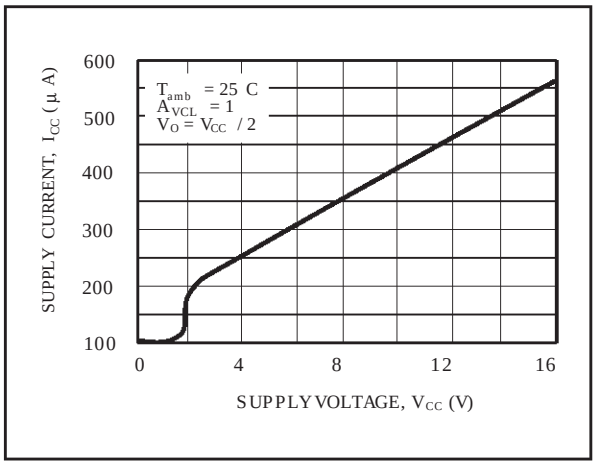


Figure 2 : Input Bias Current vs Temperature

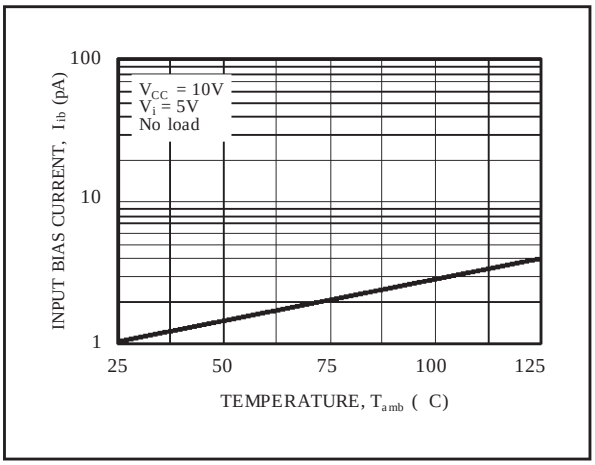


Figure 3a : High Level Output Voltage vs High Level Output Current

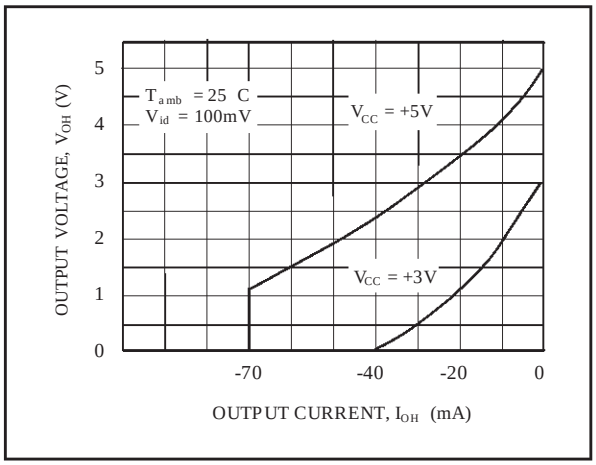


Figure 3b : High Level Output Voltage vs High Level Output Current

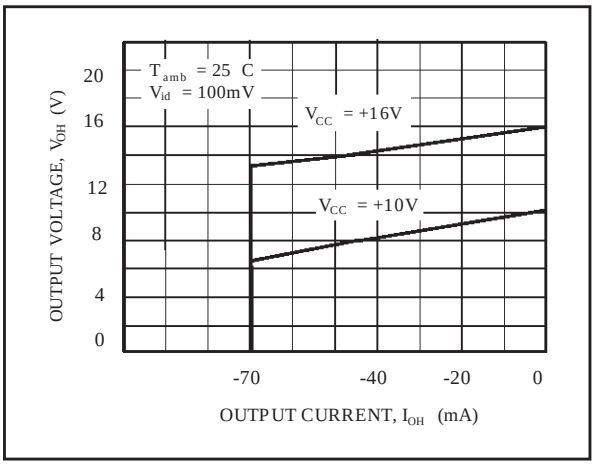


Figure 4a : Low Level Output Voltage vs Low Level Output Current

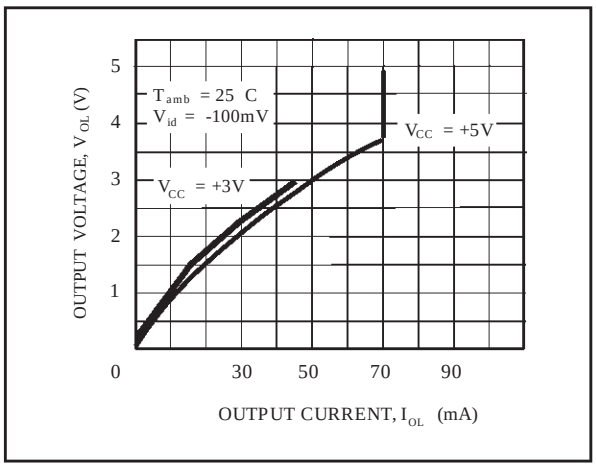


Figure 4b : Low Level Output Voltage vs Low Level Output Current

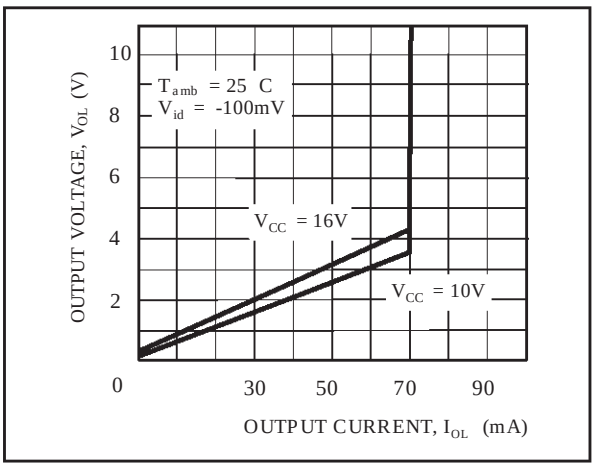


Figure 5a : Gain and Phase vs Frequency

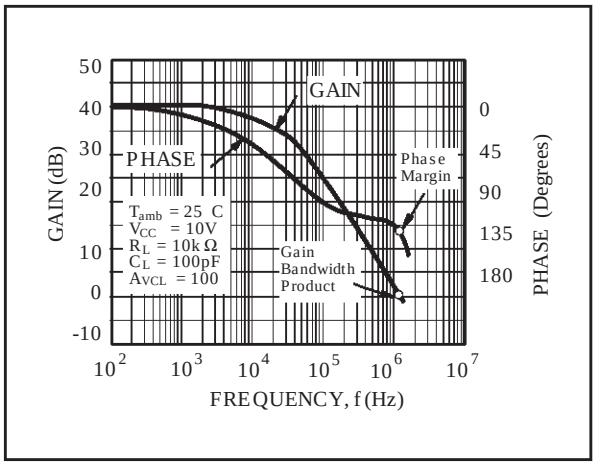


Figure 5b : Gain and Phase vs Frequency

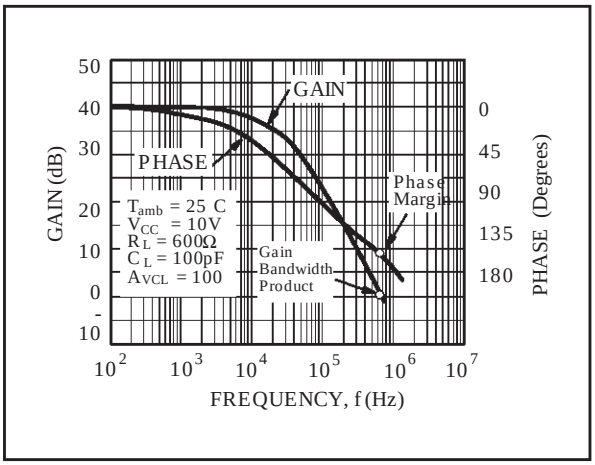


Figure 6a : Gain Bandwidth Product vs Supply Voltage

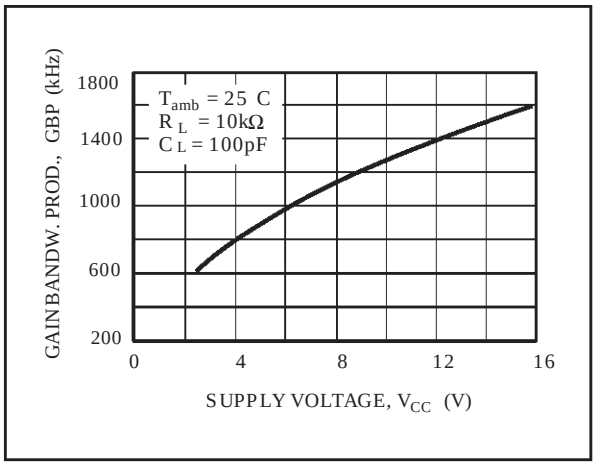


Figure 6b : Gain Bandwidth Product vs Supply Voltage

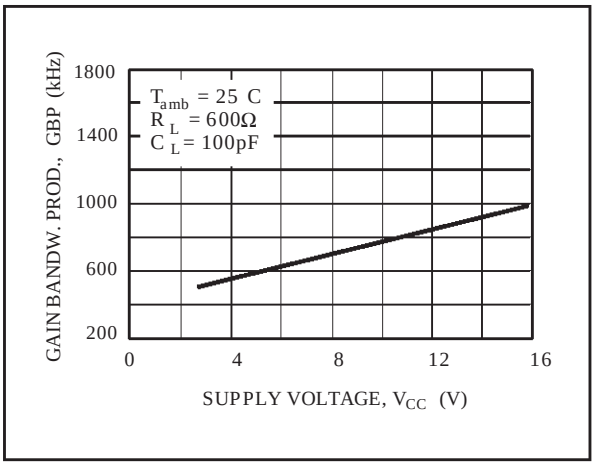


Figure 7a : Phase Margin vs Supply Voltage

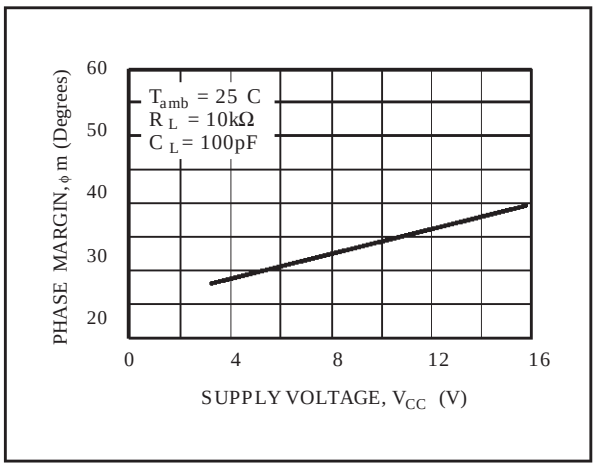


Figure 7b : Phase Margin vs Supply Voltage

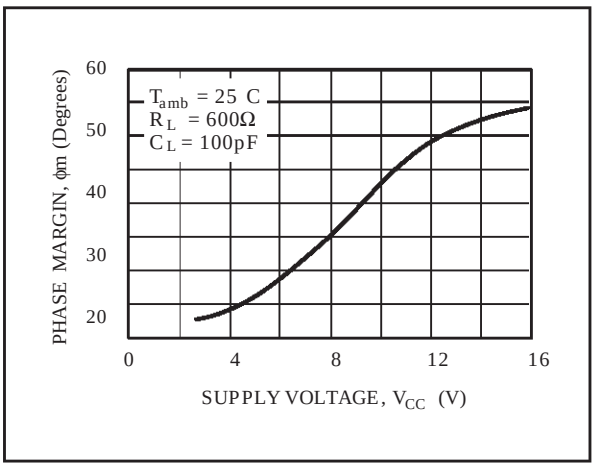
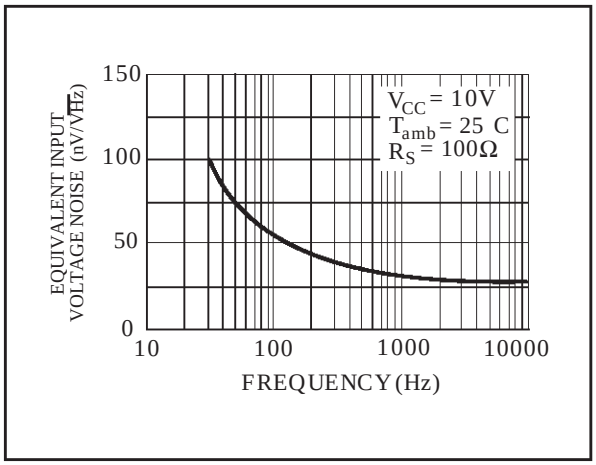


Figure 8 : Input Voltage Noise vs Frequency



MACROMODEL

Applies to : TS914i,AI,BI (V_{CC} = 3V)

```
** Standard Linear Ics Macromodels, 1993.
** CONNECTIONS :
* 1 INVERTING INPUT
* 2 NON-INVERTING INPUT
* 3 OUTPUT
* 4 POSITIVE POWER SUPPLY
* 5 NEGATIVE POWER SUPPLY
.SUBCKT TS914_3 1 3 2 4 5 (analog)
*******************************************************
.MODEL MDTH D IS=1E-8 KF=6.564344E-14 CJO=10F
* INPUT STAGE
CIP 2 5 1.000000E-12
CIN 1 5 1.000000E-12
EIP 10 5 2 5 1
EIN 16 5 1 5 1
RIP 10 11 6.500000E+00
RIN 15 16 6.500000E+00
RIS 11 15 1.271505E+01
DIP 11 12 MDTH 400E-12
DIN 15 14 MDTH 400E-12
VOFP 12 13 DC 0.000000E+00
VOFN 13 14 DC 0
IPOL 13 5 4.000000E-05
CPS 11 15 2.125860E-08
DINN 17 13 MDTH 400E-12
VIN 17 5 0.000000e+00
DINR 15 18 MDTH 400E-12
VIP 4 18 0.000000E+00
FCP 4 5 VOFP 5.000000E+00
FCN 5 4 VOFN 5.000000E+00
* AMPLIFYING STAGE
FIP 5 19 VOFP 2.750000E+02
FIN 5 19 VOFN 2.750000E+02
RG1 19 5 1.916825E+05
RG2 19 4 1.916825E+05
CC 19 29 2.200000E-08
HZTP 30 29 VOFP 1.3E+03
HZTN 5 30 VOFN 1.3E+03
DOPM 19 22 MDTH 400E-12
DONM 21 19 MDTH 400E-12
HOPM 22 28 VOUT 3800
VIPM 28 4 150
HONM 21 27 VOUT 3800
VINM 5 27 150
EOUT 26 23 19 5 1
VOUT 23 5 0
ROUT 26 3 75
COUT 3 5 1.000000E-12
DOP 19 68 MDTH 400E-12
VOP 4 25 1.724
HSCP 68 25 VSCP1 0.8E8
DON 69 19 MDTH 400E-12
VON 24 5 1.7419107
HSCN 24 69 VSCN1 0.8E+08
VSCTHP 60 61 0.0875
** VSCTHP = le seuil au dessus de vio
* 500
** c.a.d 275U-000U dus a l'offset
DSCP1 61 63 MDTH 400E-12
VSCP1 63 64 0
ISCP 64 0 1.000000E-8
DSCP2 0 64 MDTH 400E-12
DSCN2 0 74 MDTH 400E-12
ISCN 74 0 1.000000E-8
VSCN1 73 74 0
DSCN1 71 73 MDTH 400E-12
VSCTHN 71 70 -0.55
** VSCTHN = le seuil au dessous de vio
* 2000
** c.a.d -375U-000U dus a l'offset
ESCP 60 0 2 1 500
ESCN 70 0 2 1 -2000
.ENDS
```

ELECTRICAL CHARACTERISTICS

V_{CC}^+ = 3V, V_{CC}- = 0V, R_L, C_L connected to $V_{CC/2}$, T_{amb} = 25°C (unless otherwise specified)

Symbol	Conditions	Value	Unit
V_{io}		0	mV
A_{vd}	R_L = 10kΩ	10	V/mV
I_{CC}	No load, per operator	100	µA
V_{icm}		-0.2 to 3.2	V
V_{OH}	R_L = 600Ω	2.96	V
V_{OL}	R_L = 60Ω	300	mV
I_{sink}	V_O = 3V	40	mA
I_{source}	V_O = 0V	40	mA
GBP	R_L = 10kΩ, C_L = 100pF	0.8	MHz
SR	R_L = 10kΩ, C_L = 100pF	0.3	V/µs
ϕm	Phase Margin	30	Degrees

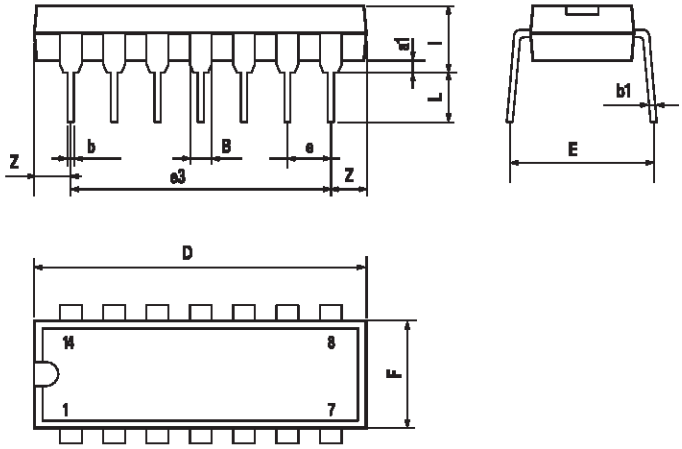
MACROMODEL

Applies to : TS914I,AI,BI (V_{CC} = 5V)

```
** Standard Linear Ics Macromodels, 1993.
** CONNECTIONS :
* 1 INVERTING INPUT
* 2 NON-INVERTING INPUT
* 3 OUTPUT
* 4 POSITIVE POWER SUPPLY
* 5 NEGATIVE POWER SUPPLY
* 6 STANDBY
.SUBCKT TS914_5 1 3 2 4 5 (analog)
*******************************************************************
.MODEL MDTH D IS=1E-8 KF=6.564344E-14 CJO=10F
* INPUT STAGE
CIP 2 5 1.000000E-12
CIN 1 5 1.000000E-12
EIP 10 5 2 5 1
EIN 16 5 1 5 1
RIP 10 11 6.500000E+00
RIN 15 16 6.500000E+00
RIS 11 15 7.322092E+00
DIP 11 12 MDTH 400E-12
DIN 15 14 MDTH 400E-12
VOFP 12 13 DC 0.000000E+00
VOFN 13 14 DC 0
IPOL 13 5 4.000000E-05
CPS 11 15 2.498970E-08
DINN 17 13 MDTH 400E-12
VIN 17 5 0.000000e+00
DINR 15 18 MDTH 400E-12
VIP 4 18 0.000000E+00
FCP 4 5 VOFP 5.750000E+00
FCN 5 4 VOFN 5.750000E+00
ISTB0 5 4 500N
* AMPLIFYING STAGE
FIP 5 19 VOFP 4.400000E+02
FIN 5 19 VOFN 4.400000E+02
RG1 19 5 4.904961E+05
RG2 19 4 4.904961E+05
CC 19 29 2.200000E-08
HZTP 30 29 VOFP 1.8E+03
HZTN 5 30 VOFN 1.8E+03
DOPM 19 22 MDTH 400E-12
DONM 21 19 MDTH 400E-12
HOPM 22 28 VOUT 3800
VIPM 28 4 230
HONM 21 27 VOUT 3800
VINM 5 27 230
EOUT 26 23 19 5 1
VOUT 23 5 0
ROUT 26 3 82
COUT 3 5 1.000000E-12
DOP 19 68 MDTH 400E-12
VOP 4 25 1.724
HSCP 68 25
VSCP1 0.8E+08
DON 69 19 MDTH 400E-12
VON 24 5 1.7419107
HSCN 24 69
VSCN1 0.8E+08
VSCTHP 60 61 0.0875
** VSCTHP = le seuil au dessus de vio
* 500
** c.a.d 275U-000U dus a l'offset
DSCP1 61 63 MDTH 400E-12
VSCP1 63 64 0
ISCP 64 0 1.000000E-8
DSCP2 0 64 MDTH 400E-12
DSCN2 0 74 MDTH 400E-12
ISCN 74 0 1.000000E-8
VSCN1 73 74 0
DSCN1 71 73 MDTH 400E-12
VSCTHN 71 70 -0.55
** VSCTHN = le seuil au dessous de vio
* 2000
** c.a.d -375U-000U dus a l'offset
ESCP 60 0 2 1 500
ESCN 70 0 2 1 -2000
.ENDS
```

PACKAGE MECHANICAL DATA

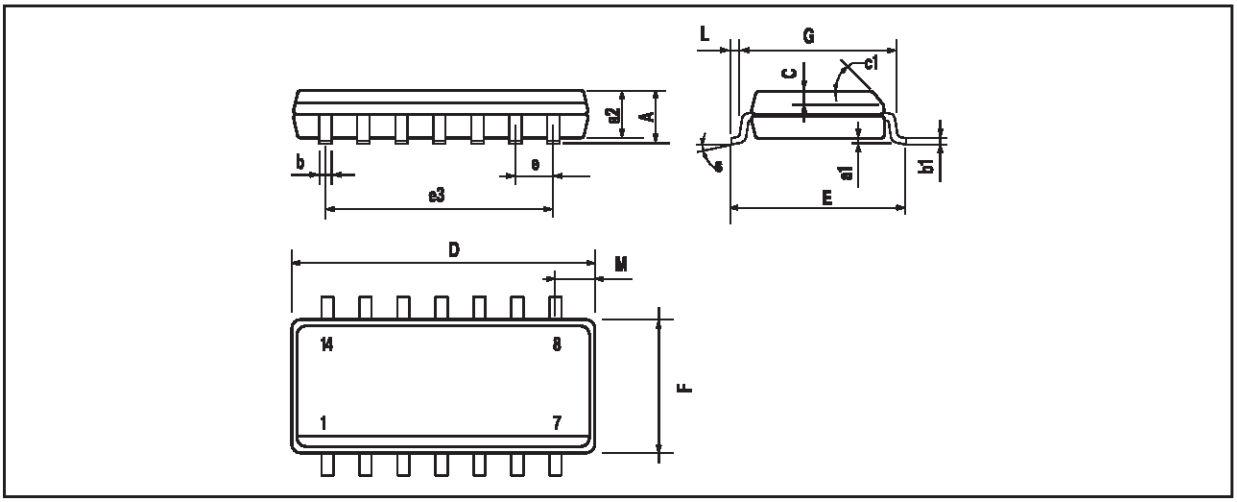
14 PINS - PLASTIC DIP



Dim.	Millimeters			Inches		
	Min.	Typ.	Max.	Min.	Typ.	Max.
a1	0.51			0.020		
B	1.39		1.65	0.055		0.065
b		0.5			0.020	
b1		0.25			0.010	
D			20			0.787
E		8.5			0.335	
e		2.54			0.100	
e3		15.24			0.600	
F			7.1			0.280
i			5.1			0.201
L		3.3			0.130	
Z	1.27		2.54	0.050		0.100

PACKAGE MECHANICAL DATA

14 PINS - PLASTIC MICROPACKAGE (SO)



Dim.	Millimeters			Inches		
	Min.	Typ.	Max.	Min.	Typ.	Max.
A			1.75			0.069
a1	0.1		0.2	0.004		0.008
a2			1.6			0.063
b	0.35		0.46	0.014		0.018
b1	0.19		0.25	0.007		0.010
C		0.5			0.020	
c1	45° (typ.)					
D (1)	8.55		8.75	0.336		0.344
E	5.8		6.2	0.228		0.244
e		1.27			0.050	
e3		7.62			0.300	
F (1)	3.8		4.0	0.150		0.157
G	4.6		5.3	0.181		0.208
L	0.5		1.27	0.020		0.050
M			0.68			0.027
S	8° (max.)					

Note : (1) D and F do not include mold flash or protrusions - Mold flash or protrusions shall not exceed 0.15mm (.066 inc) ONLY FOR DATA BOOK.